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EFFECT OF TEMPERATURE AND PHOTOPERIOD ON GROWTH AND DEVELOPMENT OF OAK TASAR SILKWORM (*Antheraea proyeli*)

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Abstract:-

Environment played a crucial role in the growth, development and survival of worms. In life history of tasar silkworm, the larvae were amenable to abiotic stress conditions which affected the morphological characters of the worms. In present investigation, vital environmental factors like temperature, and photoperiod were studied regularly to assess their impact on the life history of tasar silkworm, adult emergence, weight, length, width of larvae as well as cocoons. In addition, survivability rate, mortality rate and shell ratio were also studied. The grainage period consist of 5 groups of different temperature ranges- above 35 ℃ (gp1), 25 ℃ (gp2), 23 ℃ (gp3), 28 ℃ (gp4), below 10 ℃ (gp5) in order to study the best suitable temperature range for emergence and hatching. The results showed that temperature below 10 ℃ and above 35 ℃ hindered worm survival. The optimum temperature for normal growth of silkworm was found between 20-28 ℃ and the best suitable temperature range for maximum productivity was 23 ℃-28 ℃. Effect of photoperiod on larval stages was also studied which comprised of three groups: Group Ⅰ (13hours light : 11hours dark), Group Ⅱ (24 hours dark) and Group Ⅲ (24 hours light). Duration of life cycle, cocoon weight, quality of cocoons, shell weight and shell ratio in dark condition was significantly ($p<0.05$) better than larvae kept in normal and light conditions.

Keywords: Grainage, Temperature, Hatching, Abiotic Factors, Photoperiod

Introduction

Sericulture resulted in the creation of premium both high-protein meal for humans and animals as well as silk thread (Altman and Farrell, 2022). Sericulture is the second-largest, oldest sector for creating jobs after agriculture to over 60 lakh rural Indians. Sericulture also reduced poverty qualitatively and quantitatively and established a chain of employment for craftsmen or skilled workers from unskilled workers (Savithri *et al.*, 2013). Different species of *Antheraea* are exploited for the production of wild silk called tasar silk. These species include *A. pernyi, A. mylitta, A. proyeli, A. paphia*, which were reared in central and northern eastern parts of India. Lack in studies on tasar silkworm, *Antheraea proyeli* J. made it inexpensive and widely accessible in the temperate Himalayan area and was considered to be the perfect material for experimentation. The silkworm is poikilothermic, the abiotic factors played a vital role in the productivity and growth of silkworm (Benchamin and Jolly, 1986). The seasonal differences in the environmental components considerably affected the genotypic expression in the form of phenotypic output of silkworm crop such as cocoon weight, shell weight and shell ratio

(Chandrakanth *et al.*, 2015). The environmental factors (temperature and humidity) also influenced the carbohydrate and protein profile of silkworm, as fluctuation in temperature and low level of humidity may cause delayed and decrease in egg hatching whereas high temperature with low humidity resulted in death of embryo during early stage (Kumar *et al*., 2012). In addition to temperature and humidity, photoperiod also played very crucial role in sericulture industry. Lacking information on tasar silk of Himachal Pradesh provoked to design a research work where effect of temperature and photoperiod on different morphological parameters of cocoon and larvae was studied. This study may further be useful to silkworm rearers who are eager to contribute to tasar silk.

Material and Methods

The present study was conducted in the Central Research and Training Institute, Extension Center, district Mandi of Himachal Pradesh during month of January to June, 2023 to study the impact of temperature and photoperiod on the various developmental stages of silkworm. Cocoons of race C-27 of *Antheraea proyeli* were procured from the Extension Center and were subjected to 5 different temperature ranges in order to find the best suitable range for emergence as well as hatching.

Moth emergence

The emergence of worms under five conditions of temperature were studied. Along with temperature, the humidity data was also recorded which was found to be 78-80% throughout the experimentation. Equal number of cocoons were divided into 5 groups of different temperature ranges- above 35 ℃ (gp1), 25 ℃ (gp2), 23 ℃ (gp3), 28 ℃ (gp4), below 10 ℃ (gp5). The cocoons were placed inside the formalin sterilized room. After a course of time, moths emerged from the cocoons which were further sexed and used to produce seed eggs. The emergence % were calculated using formula:

$$\text{Emergence percentage (\%)} = \frac{\text{Total no. of emerged moths}}{\text{Total no. of cocoons}} \times 100$$

Copulation, fecundity and hatching

After mating, female moths were made to lay eggs on 2% formalin disinfected paper sheets and further washed with water following a complete procedure of sterilization. The eggs were further dried and weighed and packed into small envelops. The exprimental eggs placed in trays (30 cm × 40 cm) were examined twice a day to record the hatching time and duration. The eggs hatched in different times under different temperatures.

Selections of disease free laying eggs: Preparation of disease free layings was done by employing three tier system of mother moth examination. After oviposition for 72 hours (3 days continuously) the mother moth was examined for diseases.

Brushing of the Larvae: After eight to ten days of oviposition, the silkworm larvae hatched out from the eggs. The newly hatched larvae were brushed thoroughly on disinfected plot. The larvae were brushed within 3 days carefully with the help of camel brush.

Recording and evaluation of dead and diseased larvae: The dead and infected larvae were collected regularly and pathogen confirmation was done by microscopic examination. Similarly, larval mortality due to pest infestation was also recorded regularly.

Larval period

After hatching, the silk worms from each group were collected in triplicate and reared after disinfection of the room. Rearing was carried out in acclimatized room where temperature, and relative humidity along with pests were controlled. The effect of photoperiod on the growth of larvae was seen in each group. The entire experiment carried out in a completely randomized design (CRD) with 5 replications. First group reared in 13 hrs light and 11 hrs dark (Group Ⅰ),

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second group in 24 hrs dark (Group Ⅱ), third group in 24 hrs light (Group Ⅲ). The larvae were fed three times daily on fresh and tender leaves of *Quercus serrata* except during moulting. The larvae under moult were not disturbed. Larval parameters like larval length, width and weight were studied under all three groups. In addition, period of hatching (in days), effective rate of rearing (%), survivability rate (%), mortality rate (%), shell ratio (%), larval duration (in days) were also investigated. The data was analyzed by using one way ANOVA.

Results

Effect of temperature on cocoon

The worms completed their grainage period in the temperature range of 23-28 ^{0}C. However the temperature below 10 ^{0}Cand above 37 ^{0}C halted the development. Thus there was no emergence recorded in Group 1 and Group 5. The concluded data of emergence percentage for remaining groups viz. Group 2, 3 and 4 was showed in Fig. 1

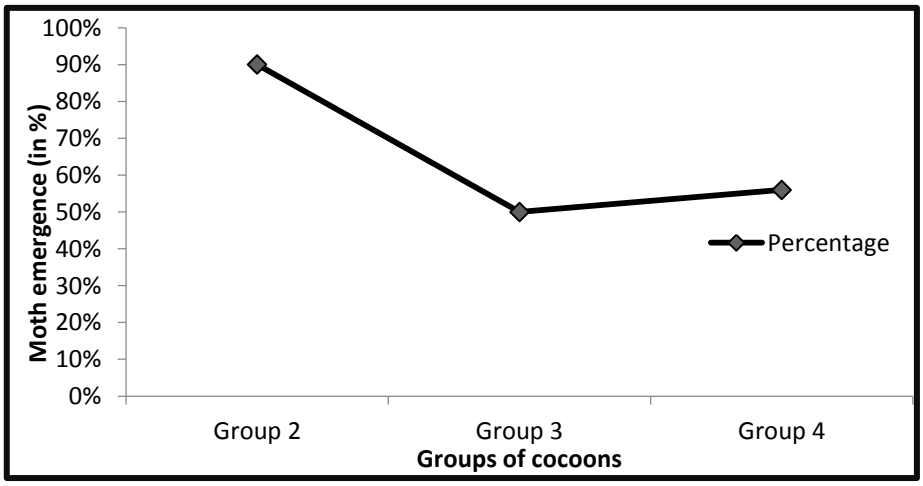

Fig 1. Emergence percentage for different groups

Fecundity i.e. the egg laying capacity was observed maximum in group 2 with temperature of 25 ^{0}C followed by group 4 and group 3 respectively. Hatching was also maximum in group 2 (Table 1)

Table 1. Fecundity and Hatchability (%) for different groups

	Group 2		Group 3		Group 4	
Replicates	**Fecundity**	**Hatchability (%)**	**Fecundity**	**Hatchability (%)**	**Fecundity**	**Hatchability (%)**
A	36	18 (50%)	30	9 (30%)	15	14 (80%)
B	32	16 (50%)	28	15 (53%)	36	18 (50%)
C	28	15 (53%)	31	10 (32%)	40	10 (25%)
D	35	16 (45%)	22	6 (27%)	30	15 (50%)
E	31	10 (32%)	28	4 (19%)	44	10 (22%)

Effect of photoperiod on larvae

Morphological parameters of larvae like length, width, weight and color of larva were studied on exposure of different photoperiodic conditions. The study showed that the morphology of larvae was different for each group with a slight variation in lengths, widths and weights of them. No effect of colour was seen throughout the experimentation.

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Comparative studies of length, width and weight of larva:

1. Length of larva for each group for different instars

The lengths of larvae at each instar stage were found to be significantly ($p<0.001$) different for each group. At 1st instar stage, the length of larva was 0.5±0.005 cm for group Ⅰ which increased in group Ⅱ (0.59±0.02 cm) and in group Ⅲ (0.8±0.04 cm). A significant ($P< 0.001$) increase in length of 2nd, 4th and 5th instars was found in gp Ⅱ while 3rd instar has its maximum length in gp Ⅰ (Fig 2).

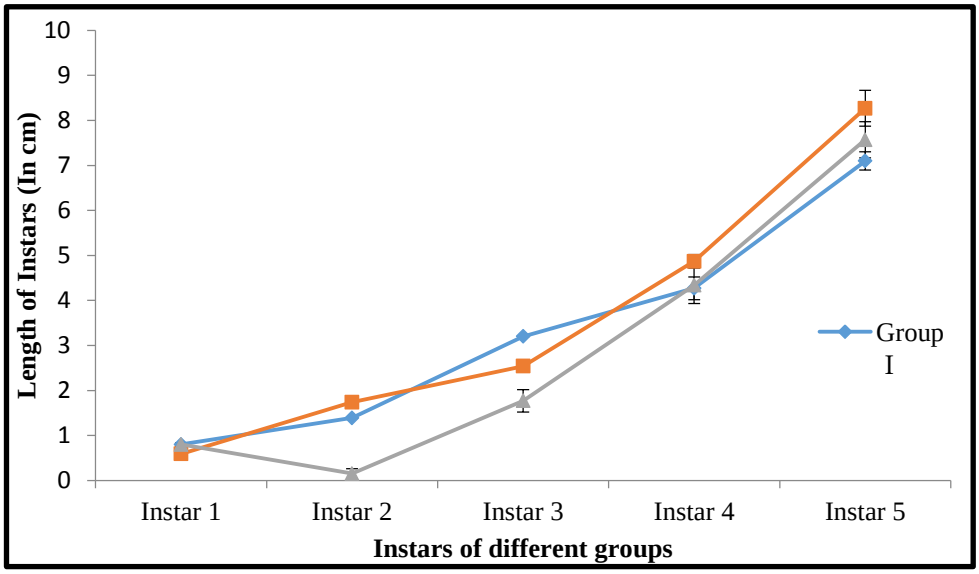

Fig.2: Graph showing length of larvae for different groups

2. Width of larva for each group for different instars

The width of larvae at each instar stages was significantly ($p<0.001$) increased in different groups. At 1st instar stage the widths were significantly ($p<0.001$) increased from 0.15±0.02 cm, 0.39±0.12 cm, and 0.48±0.02 cm for group Ⅱ, Ⅲ and Ⅰ respectively. Similarly for further developmental stages the width continued to increase and differ for each group. At the end of the larval period (5th instar stage) the width of larva was maximum for group Ⅰ (4.47±0.25 cm) followed by group Ⅲ (4.14±0.32 cm) and group Ⅱ (4.3±0.26 cm) respectively (Fig 3).

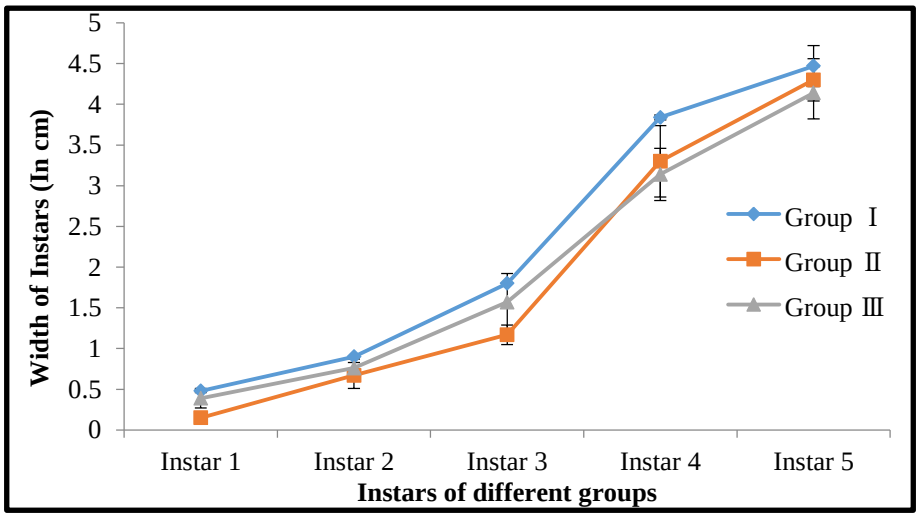

Fig. 3: Graph showing width of larvae for different groups

3. Weight of larva for each groups for different instars

At 1st instar stage the weight was found to be 0.4±0.1 gm for group Ⅰ, 0.5±0.15 gm for group Ⅱ and 0.26 ±0.05 gm for group Ⅲ. At further stages weight increased significantly ($P<0.001$) from

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0.04 ± 0.1 to 7.5±0.46 in gp Ⅰ, 0.5±0.15 to 8.17±0.25 in gp Ⅱ and 0.26±0.05 to 6.77±0.15 in gp Ⅲ. Group Ⅱ instars showed maximum gain in weight (Fig. 4).

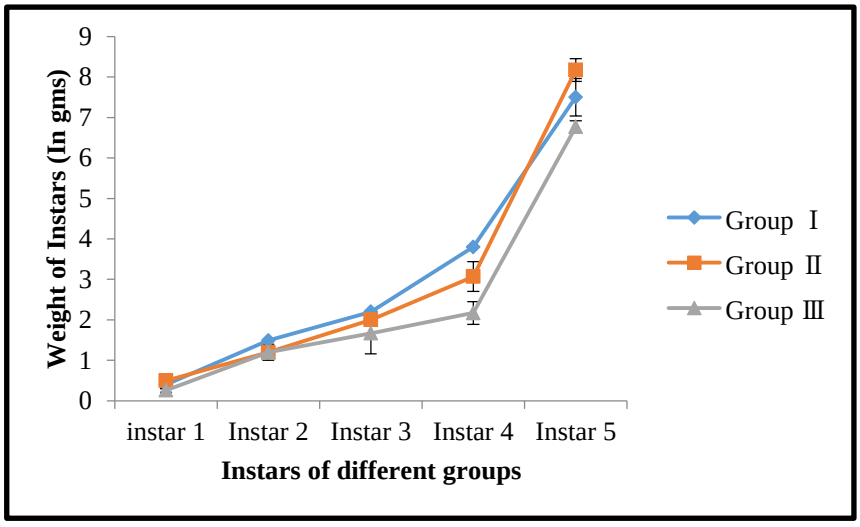

Fig. 4: Graph showing weight of larvae for different groups

Cocoon parameters

Cocoons of gp Ⅱ showed maximum increase in length (4.7±0.4), diameter (7.9±0.3), weight (5.62±0,02), and peduncle length (7.37±0.02) followed by gp Ⅰ and gp Ⅲ (Fig. 5).

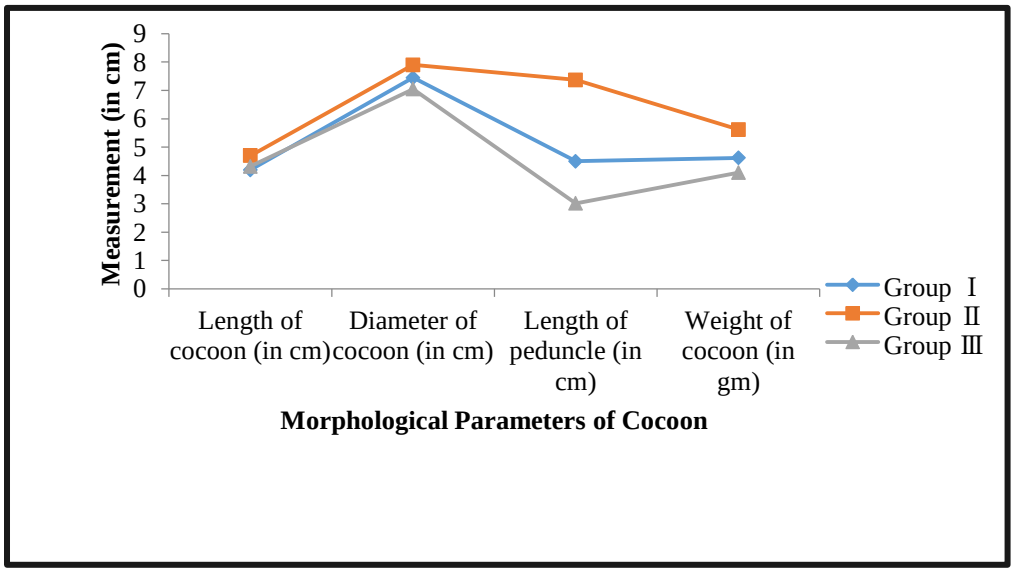

Fig. 5: Morphological parameters of cocoons

In addition to morphological parameters, some other parameters were also studied (Table 2)

Table 2: Table showing different parameters of development

PARAMETERS	Group Ⅰ	Group Ⅱ	Group Ⅲ
Period of Hatching (in days)	23	33	20
Effective Rate of Rearing(%)	16	45.4	15
Survivability Rate(%)	30	54	28
Mortality Rate(%)	69.2	45.4	72
Shell Ratio(%)	20	37.5	35
Larval duration (in days)	27	21	30

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Discussion

The variations in the environmental conditions and seasonal variations affirmed the need of management of temperature and humidity for cocoon and larval growth. Temperature has directly affected the growth, development, physiological activities, nutrient absorption, digestion, egg hatching, growth and quality of cocoons (Madhusudhan *et al.*, 2017). The present results indicated that the temperature, humidity and photoperiod greatly affected the parameters of eggs, larvae and cocoons. Silkworms are poikilothermic insects where temperature directly affected the large physiological activities of silkworm. Because of large temperature fluctuations, the growth and development of silkworm is highly affected which was confirmed by variant studies. In present study, the optimum temperature for normal growth of silkworm was found between 20-28 ℃ and the desirable temperature for maximum productivity ranged from 23 ℃-28 ℃. In addition, temperature below 10 ℃ and above 35 ℃ hindered the worm survival. In previous study of Kamble (1977) and Saha *et al.* (2013), 25-28 ℃ was ideal temperature for silkworm rearing and egg production, any fluctuations from these temperature reduced reproductive traits which was found to be similar to current investigation. The results of current study reflected that higher or lower temperature relative to 25 ℃ reduced the reproductive traits and affected the hatchability of eggs.

In order to express the effect of photoperiod, the present study showed that the larval weight, ERR%, cocoon weight, shell weight was maximum for the larvae of dark condition. According to Iqbal *et al. (*2008), the larvae kept in 24 hours light and dark provided with temperature of 25±5 ℃ and humidity of 70±10% showed that dark condition expressed better results than larvae kept in 24 hours light conditions and normal condition in respect of length and weight which was in concordant to present investigation. Sharma *et al.* (2022) also reported that at optimum conditions of temperature, humidity and photoperiodism dark conditions showed better performances as compared to light conditions.

Yadhav and Jadhav (2014) studied the effectiveness of *Philosomia ricini* larvae maintained in normal, dark and light for 24 hours for ideal temperature of 25 ± 2℃ and relative humidity of 75 ± 5%. When compared to normal condition, larvae kept in dark setting displayed better results compared to light conditions which was quite similar to current investigation.

Conclusion

It was concluded that the favourable temperature range for hatching of eggs was 25 ^{0}C. The worms of dark condition were morphologically better and the quality and quantity was also maximum for dark condition followed by the normal and light ones.

Acknowledgement

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Conflict of Interest

Authors report no conflict of interested.

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